Laser Technology for Aerospace Maintenance and Sustainment Applications

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Laser Technology for Aerospace Maintenance and Sustainment Applications	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Research Laboratory,AFRL/RXSC,Wright Patterson AFB,OH,45433**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 14-17 June 2010 in Denver, CO.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**21**	

OVERVIEW

- Problem Statement
- Air Force Laser Program
- Current Technologies
- Future Robotic Technology
- Advanced Laser Technology
- Summary

Problem Statement

Current Coatings Removal Operations At ALCs

Stripping is an expensive, time-consuming process that creates hazardous waste & emissions

Air Force Laser Program

AFRL and HQ AFMC exploring lasers for sustainment applications

Program Goal:

Establish and expand the use of laser technology as a viable alternative technology for depot maintenance operations

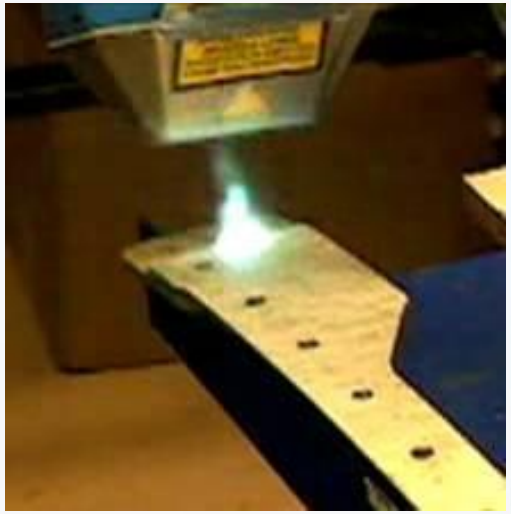
Benefits:

- ✓ Environmentally Friendly
- ✓ No Damage to Substrate
- ✓ Reduce Flow Time
- ✓ Cost Effective
- ✓ Safety Compliant
- ✓ Increase Facility Capacity

Current Technologies
Handheld Laser Coatings Removal Systems

Objective:

- Evaluate ability of hand-held laser systems to supplement existing small-area depainting processes on components and aircraft at depot and field levels



Benefits/Impacts:

- Increase production rate
- Replace Methylene Chloride, MEK, and PMB use
  - Reduce hazardous waste generation
  - Reduce handling and storage and worker exposure to known carcinogenic materials
- Potential yearly reductions at OC-ALC (based on 5,040 parts for B-52) includes:
  - 2,500 gallons paint stripper
  - 32,630 pounds of hazardous waste
  - $99,140 at OC-ALC for nitpicking operations
  - $297,500 yearly at all 3 ALCs

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Current Technologies
Handheld Laser Coatings Removal Systems (cont.)

- Evaluated 40, 120, and 500 W Nd:YAG and 250 W CO_2 handheld lasers
- Results:
  - Adequate average removal rate for small area/nitpicking operations (≈14 in^2/min)
  - No visual indication of surface damage
  - Measurements confirmed temperature spikes are not high enough to cause damage (<200° F)
  - All clad substrates tested indicated no clad penetration occurred
  - No indication of excessive surface roughness
  - Adhesion properties not adversely affected to the point of eliminating any of the lasers from consideration Fatigue and Tensile results compared to published results from other stripping methods
  - Laser stripping causes debits that are no greater than those experienced using other stripping methods

Cost Benefits Analysis Results

$100K Annual savings, $1.2M Life Cycle Cost Savings, and
2.2 year Return On Investment (ROI)

Current Technologies
Handheld Laser Coatings Removal Systems (cont.)

- Laser technology is proving to be a viable alternative to present de-painting operations as a supplemental approach
  - Results achieved during the laboratory testing were positive
- Results are being utilized by other organizations to develop laser capabilities
- Implementation of handheld laser technology into DoD
  - U.S. Air Force Depots
    - Oklahoma City Air Logistics Center (OC-ALC)
    - Ogden Air Logistics Center (OO-ALC)
    - Warner-Robins Air Logistics Center (WR-ALC)
  - U.S. Army (Ft. Rucker, AL)
  - U.S. Coast Guard Aviation Logistics Center (Elizabeth City, NC)
- Air Force proceeded with robotic laser technology for large surface area applications based upon this successful program

Handheld systems implemented and approved for use

Current Technologies
Robotic Laser Coating Removal System (RLCRS)

Objective:

- Develop robotic laser coating removal system to replace current chemical/ mechanical coating removal methods used on large off-equipment components

Benefits/Impacts:

- Reduce stripping time and replace chemical strippers, MEK, PMB and wheat starch
- Potential reductions at OC-ALC include:
  - 13,200 gallons paint stripper
  - 341,260 pounds of solid waste
  - 4003 pounds of VOCs
  - 1,815,000 gallons contaminated waste water
  - $390K savings in annual environmental costs

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Current Technologies
RLCRS (cont.)

- Design and construction of RLCRS was successful
- Material testing demonstrated the safe use of RLCRS technology
- System successfully transitioned into OC-ALC
  - Operators from all 3 shifts have been trained / used equipment at OC-ALC
  - Demonstrations have been conducted for E-3, B-1, and KC-135 Engineering Offices
- Approval for production usage has been granted by 2 of the 3 major weapon systems processed at OC-ALC
- Based on positive results Ogden ALC commissioned the design and construction of a RLCRS
- Interest from other facilities / services in acquiring robotic laser coating removal capabilities

<u>Cost Benefits Analysis Results</u>
$7.5 M Annual savings and
<1 year Return on Investment (ROI)

Current Technologies

Advanced Robotic Laser Coating Removal System (ARLCRS)

Objective:

- Replace Laser Automated De-coating System (LADS) for OO-ALC
- Integrate proven laser technology with a large robotic platform to create automated system for de-painting radomes and other off-aircraft components for both metal and composite substrates

Requirements:

- Ability to strip A-10, F-16 and C-130 radomes and off-aircraft parts
- Requires turntable and robotic track system to access most part areas
- Use commercially available and production proven laser components
- Integrate contour following to maintain accurate stand-off and focal length
- Perform stripping in +/- x direction

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Current Technologies
ARCLRS (cont.)

Benefits/Impacts:

- Uses commercially available and production proven laser components
- Able to strip A-10, F-16 and C-130 radomes and other off-aircraft parts
  - Multiple part geometries may be processed
- Real-time contour following capability – no specific path programming required
- Real-time surface temperature measurements
- Smaller footprint
- Faster strip rates
  - LADS took 4+ hours to strip F-16 radome and ARLCRS takes about 1/2 hour.
- Cost savings of ~$330,000 annually for F-16 Radomes
  - Additional savings will be realized as system is used on other large off-aircraft parts

LADS took 4+ hours to strip F-16 radome
ARLCRS (LADS II) takes about ½ hour

Current Technologies
ARCLRS (cont.)

LASER Comparison

3’x 7’x 9’ LADS II
8 kW COTS LASER
made by Rofin Sinar

VS.

LADS 6 kW LASER equipment filled a 16’x60’ room

Current Technologies
ARCLRS (cont.)

VS.

- System successfully transitioned into OO-ALC
- Currently in operation de-painting F-16 radomes
- Conducting test and evaluation with other weapons system program offices and engineering authorities to approve other components for this de-paint process
  - Working with A-10 and F-16 SPOs
  - Plan to work with F-22, B-2, and C-130

<u>Cost Savings</u>

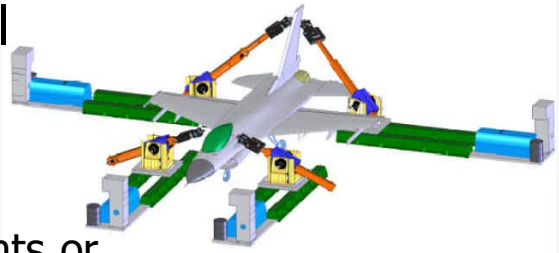
$300,000 Annual Savings for F-16 radomes

Increased capacity 80% - now able to process large off-aircraft parts

Future Robotic Technology
Full Aircraft Coating Removal Systems

Objective:

- Develop, evaluate, and implement a state-of-the-art (SOTA) Advanced Robotic Laser Coatings Removal System (ARLCRS) for large on- and off-aircraft components and/or a full aircraft system
- Two major components to make this successful
  - robotic system capable of handling a variety of components or aircraft
  - fiber laser optimized to provide increased production rate



Benefits/Impacts:

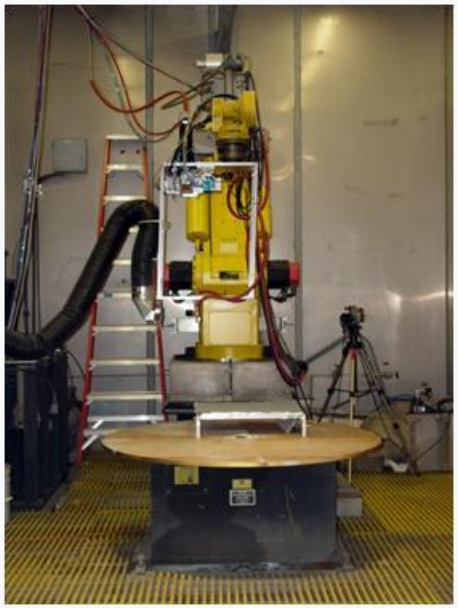
- Parts or aircraft stay in same position
- Facility space could be used for other applications

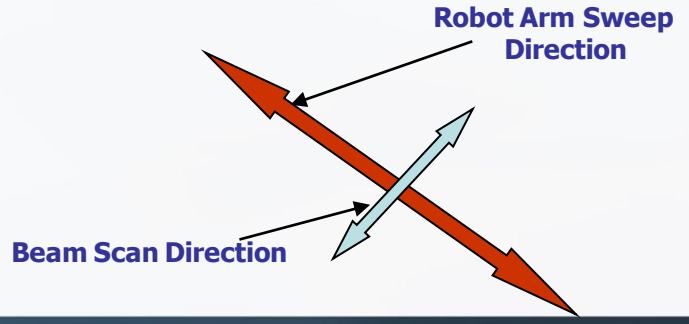
Status:

- Several conceptual designs were developed and are under consideration for full aircraft applications
- Targeted aircraft include F-16 and C-130
- Hill AFB (OO-ALC) targeted installation facility

Advanced Laser Technology

- Evaluation of high power fiber laser is underway
  - Fiber delivered laser will allow for implementation in more advanced robotic designs
  - Fiber Laser Evaluation
    - Integrated 6 kW IPG fiber laser with Fanuc robot at *CTC* for additional testing & optimization
    - Tested both Visotek and ScanLab galvo based scanners
      - Scanlab scanner using optics that produce 1 mm x 5 mm elliptical spot size
    - Scanner pattern is a straight line that is 139 mm wide





Advanced Laser Technology (cont.)

- Fiber laser now being tested on various substrate / coating combinations
  - 4 cycles of coating/laser stripping of chromated 2024 and 7075 aluminum substrates coated with a 10 mil standard MIL-PRF-23377 primer and MIL-PRF-85285 topcoat completed December 09
    - Temperature: Max temp <250° F
    - Conductivity: No statistical change from baseline conditions
    - Hardness: No statistical change from baseline conditions
    - Tensile Testing: *No statistical change from baseline conditions*
    - FatigueTesting: *No statistical change from baseline conditions*

Advanced Laser Technology (cont.)

- Based on positive results on standard aluminum and coating system fiber laser will be tested on weapon system specific systems.
  - Substrates

Substrate Description	Panel Size (inches)	Panel Thickness (inches or plies)	Associated Aircraft
Aluminum alloy: 2024-T3 Cleaning: ASTM F22-65 (or FED Spec TT-C-490-E) Surface Treatment: Sulfuric acid anodized (MIL-A-8625, Class 1, Type 2)	24”x18”	0.025”	F-16
Aluminum alloy: 2024-T3 Cleaning: ASTM F22-65 (or FED Spec TT-C-490-E) Surface Treatment: PreKote	24”x18”	0.025”	F-16
Aluminum Honeycomb Face Sheets: 0.010” thick 2024-T3 clad aluminum Core: 0.625” thick aluminum core, Hexagonal, non-perforated 3/16” cell, 0.0020” nominal foil, Al alloy 3003-H18 or H19 (Optional 5052-H38 or H-39).	24”x18”	0.010” (Face sheet thickness)	F-16, C-130
Aluminum Honeycomb Face Sheets: 0.016” 2024-T3 clad aluminum Core: Same as above	24”x18”	0.016” (Face sheet thickness)	F-16, C-130
Aluminum Honeycomb Face Sheets: 0.020” 2024-T3 clad aluminum Core: Same as above	24”x18”	0.020” (Face sheet thickness)	F-16, C-130

Advanced Laser Technology (cont.)

- Coating Systems to be tested

Coating	Specification[1]	Thickness (mils)	Manufacturer (Part Number)	Color	Aircraft
Primer	MIL-PRF-23377, Type 1, Class C2	0.6 – 0.9	Sherwin Williams (SW) (E90G203/V93V230) or PPG (EEAY051A)	Yellow	F-16, C-130
Topcoat	MIL-PRF-85285, Type 1, Class H, APC	9	Deft Extended Life (99GY001) or PPG (CA9311/F36173)	Gray	
Primer	MIL-PRF-23377, Type 1, Class C2	0.6 – 0.9	SW (E90G203/V93V230) or PPG (EEAY051A)	Yellow	C-130
Mid-Coat	A-A-59166, Type 2, Non-skid walkway coating	30-50	Hentzen (8010-00-641-0426)	N/A	
Primer	MIL-PRF-23377, Type 1, Class C2	0.6 – 0.9	SW (E90G203/V93V230) or PPG (EEAY051A)	Yellow	
Topcoat	MIL-PRF-85285, Type 1, Class H	9	Deft Extended Life (99GY001) or PPG (CA9311/F36173)	Gray	

Advanced Laser Technology (cont.)

- Panels are now being prepared and 4 cycle coating/stripping is underway
- At the completion of the 4 cycle stripping mechanical testing will be performed
  - **Aluminum Substrate:** Strip Rate, Visual Assessment, Substrate Temperature, Electrical Conductivity, Rockwell Hardness, Tensile, Smooth and Notched Fatigue
  - **Metallic Honeycomb:** Strip Rate, Visual Assessment, Substrate Temperature, Coin Tap, Peel Resistance, Flat-wise Tensile
- Final test results will be available in Summer 2010

Summary

- Laser technology is proven and in use
  - DoD laser coating removal efforts have positively demonstrated technology (i.e., RLCRS at OC-ALC and LADS II at OO-ALC)
- Results achieved during laboratory testing and system transition activities are positive
- Work is moving towards full aircraft coatings removal and specialty coatings removal applications

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